TITLE

METHOD AND APPARATUS FOR VIBRATION CASTING OF VEHICLE WHEELS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/092,684, filed on July 13, 1998 and International Patent Application No. PCT/US99/15719, filed on July 12, 1999.

BACKGROUND OF THE INVENTION

This invention relates in general to casting of vehicle wheels and in particular to a method and apparatus for vibration casting of vehicle wheels.

Vehicle wheels include a circular wheel disc attached to an annular wheel rim. The wheel disc includes a central wheel hub having a pilot hole and plurality of wheel mounting holes formed therethrough. A plurality of equally circumferentially spaced radially extending spokes support the wheel hub within the wheel rim. The wheel rim is adapted to support a pneumatic tire.

In the past, vehicle wheels typically have been formed entirely from steel. However, one piece wheels formed entirely from light weight metals, such as aluminum, magnesium and titanium or alloys thereof, are becoming increasingly popular. In addition to weighing less than conventional all-steel wheels, such light weight wheels can be manufactured having a pleasing esthetic shape. Weight savings also can be achieved with two piece wheels formed by attaching a light weight metal alloy wheel disc to a steel wheel rim.

Light weight wheels are typically formed by forging or casting operations. During a forging operation, a heated billet of the light weight metal alloy is squeezed by very high pressure between successive sets of dies until the final shape of the wheel is formed. During a casting operation, molten metal is poured or forced under pressure into a cavity formed in a multi-piece wheel mold. After the metal cools

sufficiently to solidify, the mold is opened and a rough wheel casting is removed. The wheel casting is then machined to a final shape. Machining can include turning the outside and inside surfaces of the wheel rim, facing the inboard and outboard wheel disc surfaces and drilling the center pilot hole and the mounting holes through the wheel hub.

Conventional casting operations include numerous processes, such as die casting, low pressure injection casting and gravity casting. Conventional casting operations typically utilize a wheel mold formed from a number of movable segments which are opened to allow removable of the wheel casting from the mold. Referring now to the drawings, there is illustrated in Fig. 1, generally at 10, a typical multi-segment wheel mold used for gravity casting. The mold 10 includes a base segment 11 which supports a plurality of movable side segments 12, two of which are shown in Fig. 1. The side segments 12 can be retracted and extended in a horizontal direction by a conventional mechanism 13. A movable top core 14 extends between the side segments 12. The top core 14 can be raised and lowered in a vertical direction by the mechanism 13. When the mold 10 is closed, the top core 14 cooperates with the side and base segments 12 and 11 to define a wheel mold cavity 15. The outline of a finished vehicle wheel cast in the mold 10 is illustrated in Fig. 1 by the dashed line labeled 16.

For high volume production of castings, such as vehicle wheels, a highly automated gravity casting process is frequently used. Such automated gravity casting processes typically use a casting machine having a plurality of multi-segment molds mounted upon a moving structure, such as a rotatable carousel. Each mold is indexed past a refractory furnace containing a pool of molten metal. A charge of molten metal is poured into a gate formed in the mold which communicates with the mold cavity. Gravity causes the metal to flow from the gate into the mold cavity. The mold and the molten metal cool as the casting machine indexes the other molds to the refractory furnace for charging with molten metal. After a sufficient cooling time has elapsed for the molten metal to solidify, the mold is opened and the wheel casting removed. The

mold is then closed and again indexed to the refractory furnace to be refilled with another charge of molten metal.

SUMMARY OF THE INVENTION

This invention relates to a method and apparatus for vibration casting of vehicle wheels. As explained above, casting of vehicle wheels is a highly automated process. However, the production of a casting machine is constrained by the length of time required for the molten metal to solidify within the individual wheel molds. A reduction in the length of time needed for the molten metal to solidify would allow an increase in the speed of operation of the casting machine, thereby increasing the number of wheels produced in a given time period. Accordingly, it would be desirable to reduce the length of time needed for the molten metal to solidify.

The present invention contemplates an apparatus for casting a vehicle wheel component which includes a multi-segment mold for the vehicle wheel component and a device for vibrating a portion of the mold. In the preferred embodiment, the device for vibrating includes a pneumatically powered ball vibrator. The ball vibrator is mounted adjacent to the mold and is operable to vibrate a top core of the mold. The wheel component can be either a one piece vehicle wheel or a full face wheel disc.

Alternately, the device for vibrating can be a pneumatically powered reciprocating hammer.

The invention also contemplates a method for forming a vehicle wheel component which includes providing a multi-segment mold for casting the wheel component and a device for vibrating a portion of the wheel mold. The cavity of the wheel component mold is filled with a charge of molten metal. A portion of the wheel component mold is vibrated while the molten metal solidifies. The wheel component casting is then removed from the mold. The molten metal can be poured into the mold cavity with gravity causing the molten metal to flow throughout the mold cavity or forced under pressure into the mold cavity with the pressure causing the molten metal to flow throughout the mold cavity.

Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of a multi-segment vehicle wheel mold according to the prior art.

Fig. 2 is a sectional view of a multi-segment vehicle wheel mold in accordance with the invention.

Fig. 3 is a sectional view of a multi-segment vehicle wheel mold equipped with an alternate embodiment of the invention.

Fig. 4 is a flow chart for a method for casting a vehicle wheel in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The inventor has determined that vibrating a wheel mold can significantly reduce the amount of time needed for the molten metal contained within the mold cavity to solidify. Referring again to the drawings, there is illustrated in Fig. 2 a multi-segment wheel mold 20 used for gravity casting of wheels which is in accordance with the present invention. Components of the mold 20 which are similar to components shown in Fig. 1 have the same numerical designators. As shown in Fig. 2, a conventional commercially available ball vibrator 21 is mounted upon the mold top core 14. The vibrator 21 is secured to the top core 14 by a plurality of threaded fasteners 22. In the preferred embodiment, the vibrator 21 selected has a base which fits upon the top core 14 to minimize installation effort and time.

In the preferred embodiment, the vibrator 21 is operated by compressed air supplied though an air line 23; however, the invention also can be practiced with ball vibrators operated by other mediums, such as a hydraulically powered vibrator, or the vibrator can be powered by an electric motor. For the vibrator 21 shown, compressed air forces a chrome steel ball around bearing grade races to impart vibratory energy

through the top core 14 to the molten metal contained in the mold cavity 15.

The compressed air, which is not affected by the high temperatures encountered in a foundry, can be supplied from a readily available source, such as tapping into the foundry air supply. The compressed air flows though a regulator (not shown) for controlling the pressure to adjust the speed and force of the vibrator. In the preferred embodiment, the air pressure is adjustable over range of from 60 pounds per square inch (psi) to 100 psi.

The compressed air also flows through either a manual valve or a solenoid valve (not shown) which is connected between the regulator and the vibrator 21. The valve controls the operation of the vibrator 21. In the preferred embodiment, a solenoid valve is utilized with the valve coil connected to a microprocessor which controls the casting machine. This assures that the vibrator 21 is actuated during the appropriate periods in the cycle. A filter (not shown) also is included in the air supply to remove an contaminants from the supplied air which may damage the vibrator 21. The compressed air is vented from the vibrator 21 through an exhaust port 24. An optional muffler (not shown) can be attached to the exhaust port 24 to reduce the noise generated by the discharge of the compressed air.

The inventor has found that vibration of the mold 20 while the molten metal contained therein solidifies has significantly reduced the solidification time for a wheel casting. During tests, the solidification time has been reduced from six minutes without vibration to 4 to 5 minutes. Thus, vibration can reduce solidification time by 20 to 33 percent. Additionally, the inventor has observed that, with vibration, the microstructure grain size of a wheel casting is reduced from the size resulting without vibration. Also, the spacing of the dendrite arms within the casting is reduced when the mold is vibrated while the metal solidifies. Accordingly, the tensile strength of the wheel is improved by the application of vibration.

An alternate embodiment of the invention is illustrated by the mold 30 shown in Fig. 3. As before, components of the mold 30 which are similar to components shown in Fig. 1 have the same numerical designators. As shown in Fig. 3, a conventional pneumatic knock out hammer 31 is mounted adjacent to the mold top

core 14. The hammer 31 is held in position by a mounting bracket (not shown) which is attached to the mold support mechanism 13. The hammer is 31 actuated by compressed air supplied through an air line 32. Similar to the ball vibrator 21 described above, the compressed air is vented through an exhaust port (not shown). The hammer 31 has a reciprocating head 33 which is located adjacent to a top plate 34 of the mold top core 14. When actuated, the hammer head 33 taps the top plate 34 to impart vibrations through the top core 14 to the molten metal contained within the mold cavity 15. Operation of the hammer 31 produces results similar to those described above for the ball vibrator 21.

While the preferred embodiments of the invention have been illustrated and described above for a ball vibrator 21 and a knock out hammer 31, it will be appreciated that the invention also can be practiced with other conventional devices for imparting vibrations to the wheel mold 10. Furthermore, while gravity casting has been shown and described above, it will be appreciated that the invention also can be practiced with other conventional casting processes, such as, for example, low pressure and die casting.

The present invention also contemplates a method for vibratory casting of a vehicle wheel. The method is illustrated by the flow chart shown in Fig. 4. In functional block 40, a wheel mold, which is equipped with a vibratory device, is charged with molten metal. The metal may be poured under gravity or injected into the mold cavity by a low pressure. The vibratory device is activated in functional block 41. The mold is then vibrated in functional block 42 for a predetermined time period, T_1, which is a function of the volume of metal being cast. In the preferred embodiment, the vibration time is between 200 and 250 seconds; however, it will be appreciated that the invention also can be practiced with other vibration time periods. At the end of T_1, the vibratory device is turned off, as shown in block 43. The mold and casting are allowed to continue to cool for a additional time period, T_2, in functional block 44; however, this step is optional. In functional block 45, the mold is opened and the wheel casting removed therefrom.

Additionally, the method can be practiced with vibration being applied to the mold while the mold cavity is being charged with the molten metal (not shown). Similarly, the method can include a delay before actuating the vibrator to allow the mold to be charged with molten metal and for the molten metal to be begin to solidify. In the preferred embodiment, the delay is in the range of from zero to 30 seconds; however, it will be appreciated that the invention also can be practiced with delays which exceed 30 seconds.

While the preferred embodiment of the invention has been illustrated and described with vibration applied to the top core of a wheel mold, it will be appreciated that the invention also can be practiced with the vibration applied to other portions of the mold, such as, for example, to a side segment (not shown). Additionally, vibration can be applied simultaneously to a plurality of mold segments (not shown).

In accordance with the provisions of the patent statutes, the principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope. For example, while the preferred embodiment of the invention has been illustrated and described for casting a one piece wheel, it will be appreciated that the invention also can be practiced for casting a component of a vehicle wheel, such as a full face wheel disc or a wheel rim.